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ABSTRACT

The bewildering number of available terminals which are offered to CAI users presents a rather formidable problem of which one to choose. This article surveys what appear to be evolving standards for terminals. The usefulness of these terminals for CAI purposes is discussed, together with the best known prototype exhibiting the particular feature. Based on different technological requirements, terminals may be classified into the following five categories: (1) typing terminals, capable of displaying alphameric information only, with hardware character generators; (2) Cathode Ray Tube (CRT) terminals, capable of displaying alphameric information only; (3) CRT terminals with programmable character generators, capable of displaying pre-stored graphic information; (4) CRT terminals with the ability of addressing each point on the screen, capable of displaying generated graphic information; and (5) video terminals capable of displaying moving pictures in addition to full graphic capability. The characteristic technology, and advantages and disadvantages for each of these five classes of terminals is discussed. (Author/VT)

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CAI TERMINAL CHARACTERISTICS

by

Peter Braun

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CAI TERMINAL CHARACTERISTICS

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The bewildering number of available terminals which are offered to CAI users presents a rather formidable problem: which should one choose? As each distributor generally sells only one product, comparative information is difficult and time consuming to obtain. This article surveys what appear to be evolving standards for terminals. The usefulness of these terminals for CAI purposes is discussed, together with the best known prototype exhibiting the particular feature.

Based on different technological requirements, terminals may be roughly classified into the following five categories:

A. Typing terminals

B. Simple CRT terminals

C. Semi-graphic CRT terminals

D. Full-graphic CRT terminals

E. Video display terminals

The characteristic technology, and advantages and disadvantages for each of these five classes of terminals is discussed below.

A. Typing Terminals

The natural choice for the first CAI terminals were already existing telecommunication machines such as the TELEX Teletype. Its low cost made it an attractive choice for a terminal, but there are some who claim that the availability of this type of terminal retarded CAI for at least ten years. The high noise levels and slow printing speeds of typing terminals such as the Teletype or the IBM 2741 have led educators to frown on CAI as a classroom tool (except in schools for the deaf), frequently abandoning CAI as a feasible alternative method of instruction in the process.

These early limitations of typing terminals have been largely overcome. Modern typing terminals, such as the dot printers, or ink-jet printers, operate nearly noiseless, print faster than reading speed, and are available at low cost.

1. Technical Characteristics

a. Dot printers have a small printhead featuring a single column of vertically arranged wires--usually seven in number. Upon moving the printhead across the paper, these wires are fired at appropriate times to formulate the character images. Since the printhead features only a single column of wires, it must move across

the character space for printing purposes. Most dot printers print both forward and backward, thus creating an erratic movement pattern for the printhead when data is entered from the keyboard.

Dot printers can achieve printing speeds in excess of 100 characters/second. This is much faster than average reading speed. Therefore, lengthy material can be printed without having students wait excessively for the printer to finish.

Theoretically, dot printers are capable of producing full graphics. In practice, this has not been achieved for two reasons. (1) They generally have only one or two hard-wired character sets, which do not allow the printing of configurations needed for graphics. (2) The column of print-wires does not extend over the space between print-lines; hence, continuous vertical displays can not be drawn. An example of a dot printer is the DECwriter.

b. Ink-jet printers pass a small jet of magnetized ink through magnetic deflectors which deflect the ink-jet such that it "writes" the character. Since this printer has almost no moving parts, it is fast and noiseless, giving a print quality superior to the dot printer. Some available ink-jet printers are presently manufactured by IBM.

2. Advantages of Printing Terminals

The availability of hardcopy output has frequently been cited as a major advantage of printing terminals. This is likely so where developmental work is done: a trace of the work may be important. When doing CAI, the CAI system records a trace of each student's progress through a course. Experience has shown that hardcopy output of completed coursework is generally "filed" away. Thus, it is of small importance in CAI work. Students should experience the CAI system like a library resource: the courses they have taken via CAI are waiting to be re-taken as often as desired--like the books in the library are waiting to be read. This alleviates the need to purchase the library books, or to take hardcopy of a course.

3. Disadvantages of Printing Terminals

With the elimination of slow operating speed and the noise factor, the disadvantages of printing terminals for CAI have become marginal. One could cite ongoing operating costs, such as paper, ribbons, and ink as being a disadvantage in comparison to CRTs. Another disadvantage might be the lack of rapid scrolling which can be used on CRTs to skip unwanted portions of a course.

Perhaps the major restriction of typing terminals is that they are exclusively suited for presenting written material. A student must be able to read and type to operate the keyboard in order to interact with a typing terminal. While auxiliary devices, such as a slide

projector or tape recorder, can be operated concurrently to allow graphic or audio support, they often add a fair level of operating complexity which distracts from learning.

B. Simple CRT Terminals

The term "CRT terminal" has been commonly accepted to denote all display panel devices, even though some do not use a Cathode Ray Tube. For convenience, it will be used in this fashion here.

1. Technical Characteristics

The most commonly available CRTs fall into the category of "simple CRT terminals." They are generally capable of displaying about 24 lines of 80 characters, for a total of 1920 characters. Most CRTs need to be refreshed, that is, similar to a TV set, the image on the CRT must be re-written several times per second to avoid dimming or flicker. Therefore, CRTs usually have a local memory, or buffer, which holds all the information to be displayed on the screen. This buffer is loaded by the computer with the information to be displayed, and on the next refresh cycle, the content of the buffer is read and shown on the screen. The information is passed through a character generator which translates the bit-structure of the buffer into the appropriate character image, and displays it on the screen in the appropriate character rectangle corresponding to the buffer location.

In general, each of the buffer locations is addressable and can be selectively modified, allowing for such effects as blinking through periodic erasure and re-display, or changing portions of the display. While theoretically an eight bit buffer structure would permit the display of up to 256 different character images, this would necessitate an extensive character generator. Frequently, character generators in available terminals provide for no more than 48 different symbols, with additional ones being available only at extra cost.

The dominant characteristic of the "simple CRT terminal" is a hard-wired character generator. In other words, the available character set is fixed and can only be changed by physical modification of the terminal. One could, of course, have several character generators installed, and select the appropriate one either under program control, or by means of a switch on the terminal. This would be similar to changing the typeball on a Selectric typewriter, and would be required if one wanted to use the terminal for programming in languages such as APL. Since character generators are rather expensive, it would not be reasonable to provide a large number.

2. Advantages of Simple CRT Terminals

As compared to printing terminals, CRTs are perfectly noiseless. Information can be displayed as fast as the computer and transmission lines permit. Rapid scrolling of data files, or course material is

possible. Pointing devices can be attached which permit the student to point at a menu of choices displayed on the screen rather than respond only via the keyboard. This can greatly speed up passage through a course as there is no need to look away from the screen. CRTs are relatively more maintenance free than printers, requiring no paper, ribbons, or ink.

3. Disadvantages of Simple CRT Terminals

Due to their limited character set, simple CRTs feature the same disadvantages as printers with regard to graphic displays: they simply have no graphic capability. Students must be able to read as all information is presented in written format.

C. Semi-Graphic Display Terminals

There are two characteristics which differentiate a semi-graphic CRT from a simple CRT: it must have a programmable character generator, and the rectangles used for displaying characters must have adjacent boundaries with no intervening blank space. If these two conditions are met, one can assemble line drawings where each line segment running through a character rectangle has been defined as representing a character. The first commercially available prototype of such a terminal was attached to the IBM 1500 CAI system.

1. Technical Characteristics

Since the smallest addressable space on the screen is a character rectangle, only graphics composed of a defined pattern can be represented. Each smallest part of the graphic picture is the size of a character. Note that on simple CRTs and dot printers, the character is generally embedded in a 7 x 5 dot matrix rectangle. On semi-graphic CRTs, the character rectangle is customarily a 12 x 7 dot matrix. The character still consumes only about 9 x 6 of this space, with the remainder being used to create the boundaries around the character. However, these boundaries can be filled in as required when creating continuous lines for graphic displays. Hence, these terminals permit the showing of uninterrupted lines through the design of special characters which can be loaded under program control into the customary character generator to replace some or all of its content.

2. Advantages of Semi-Graphic Display Terminals

The capability to replace character sets under program control adds a tremendous flexibility to the terminal for CAI purposes. This flexibility is so important for all but verbal presentations that terminals without this feature can really not be called "CAI" terminals. The replaceable characterset provides a major stepping stone in making a terminal useful for CAI.

3. Disadvantages of Semi-Graphic Display Terminals

Obviously, additional costs are involved. Also, a fair amount of software is required to facilitate the proper design of special characters on the screen. This software is now generally modelled after the first such package which was developed and implemented at the University of Alberta on the IBM 1500 system.

D. Fully Graphic Display Terminals

1. Technical Characteristics

The dominant characteristic of a fully graphic terminal is that not only can one address character rectangles, but also each dot on the screen is addressable. Given supportive software, this allows the drawing of lines between any two dots, either straight or curvilinear, to generate any desired drawing. The best known example of such a fully graphic terminal is the PLATO terminal.

2. Advantages of Fully Graphic Display Terminals

Terminals such as PLATO satisfy the most demanding display request imaginable. Supporting software exists to draw characters of any size or shape at any angle of display. Lines and circles can be created via software routines to compose complex pictures. Processing is sufficiently fast to create an impression of slow motion, such as a growing snowflake. The true potential of this type of terminal has only been scratched at this time since many teaching techniques making full use of this technology have not yet been invented. It is capable of handling the most imaginative learning applications.

E. Video Display Terminals

The video terminals are one step beyond the full graphic terminals: apart from displaying alpha-numeric and graphic information, they can be used to show motion pictures, usually in full color. In fact, most video terminals use existing TV technology. The digital and graphic display information from the computer is simply mixed with output from a video source (e.g. video tape player) to create the desired screen effect. An example of a system using this technology is TICCIT.

1. Technological Characteristics

A fairly large amount of special hardware is required to operate a video CAI system. However, it is the ultimate in interactive, automated teaching. Programming is relatively easy as the information required by the system can be entered in pictorial form, that is, a frame of information can be treated like a picture, and can be stored on a random access video disk or other video storage device. Video

films can be interspersed at appropriate points in the program for demonstration of learning principles or other effects. Presently, these films would need to be retrieved from a video library and loaded onto video tape players whose output signals can be mixed with the appropriate terminal signal. However, new laser beam technology promises to simplify this problem in the near future.

2. Advantages of Video Display Terminals

The overwhelming advantage is the possibility of designing curriculum with almost no restriction. Whatever the eye sees or the ear hears in the real world can be replicated by a course author on a video terminal. Note, however, that the TICCIT system is not an example of a system permitting this kind of authoring capability. Authoring freedom on TICCIT has been purposely reduced to simplify authoring and reduce system overhead.

Another advantage is the low cost. Since video terminals use mass-produced TV-technology components, they are much less costly than any of the other types of terminals.

3. Disadvantages of Video Display Terminals

One might wonder why the low cost and enormous flexibility of the video technology has not made it the automatic choice of the educational community. There are two reasons: first, CAI is most frequently done in "piggy-back" mode, that is, it is added to a computer which exists and has been cost-justified for other purposes. A video-based CAI system needs a lot of dedicated special purpose hardware which can not be used or cost-justified for other purposes (e.g., administration). Second, the home television set has trained TV viewers to expect rather sophisticated and professional presentations. It would be quite a challenge for educators to match the talent and creativity of the entertainment industry when designing courses for video display terminals. Also, a considerable amount of money would be required for this design work.

SUMMARY

Five types of commonly available terminals have been discussed. These were:

A. Typing terminals, capable of displaying alphameric information only, with hardware character generators.

B. CRT terminals, capable of displaying alphameric information only.

C. CRT terminals with programmable character generators, capable of displaying pre-stored graphic information.

D. CRT terminals with the ability of addressing each point on the screen, capable of displaying generated graphic information.

E. Video terminals capable of displaying moving pictures in addition to full graphic capability.

The terminal types A and B are the most frequently found terminals. Since they can only display alphameric information, their suitability for CAI is relatively limited. Type C would appear to be a minimal requirement for a CAI terminal. It permits presentations with predefined graphic displays to enhance understanding. Type D is the most sophisticated CAI terminal presently commercially available. Its technology is fully developed. A somewhat restricted version of Type E is now in production (TICCIT), while a less restricted version is at the operational stage at the University of Waterloo in Canada. Substantial enhancements of Type E terminals can be expected with video disk storage based on laser technology.

IMPLICATIONS

Since this paper is intended to provide an overview of the most important terminal characteristics, many details have been left out. These are, however, generally minor when compared to the major classifying characteristics presented here. A prospective terminal buyer not only needs to know his own intended applications and the terminal characteristics required for these applications, but also the amount of course material which is already available to him from other sources. While some adaptation of course material is almost always necessary, it is much easier to adapt a course which has already been developed and debugged, rather than to start from scratch to re-invent the same wheel. However, there are degrees of difficulty. A course making use of a pointing device can be modified with relative ease to work on a similar terminal without such a device, but a course written for a Type C terminal can not be adapted to a Type B or Type A terminal. This limitation must be kept in mind when deciding on suitable terminals.